February 25, 1949

MEMORANDUM to Mr. W. H. Bradley, Chief Geologist, through Mr. Carle H. Dane, Chief, Fuels Branch, Geologic Division:

SUGGESTED RESEARCH PROGRAM ON GEOLOGY AND RELATED STUDIES OF POISONOUS ROCKS

This suggested research program on geological studies, coordinated with geobotanical studies and geochemical studies of rocks containing selenium, molybdenum, tellurium, and other poisons was prepared in accordance with your instructions of February 7, 1949, at Salt Lake City, Utah. It is as brief as time and the wealth of data permit, and is written as simply as I can treat such a complicated subject. Fourteen plates and one chart are included.

At the interregional meeting of various Geological Survey groups in Salt Lake City, February 4 to 9, 1949, repeated statements were made of the need for the integration of work by various groups with diverse interests in order to secure the maximum tax dollar value and man-hour of work in the public interest. Repeated statements were also made, as indeed they have been made at every major meeting of geologists since World War II began, of the great need for bridging the gap between geology and the public.

The program outlined here will save the taxpayers millions of dollars and millions of man-hours of work if it is integrated properly with programs of other Federal bureaus for the result will be a more sound basis for plans involving public lands and public lands policies.

The program outlined here will bring geology, geobotany, and geochemistry to the homes of farmers, ranchers, and other property-owners throughout vast areas of the western United States (see Plates 6, 8, 10, 12, and 14). If this program is properly effected, it will save these people millions of dollars, by preventing livestock deaths, preventing livestock and human debility, preventing the raising of poisoned crops, eliminating poisoned pastures, and preventing unwise investments in land and livestock.

I wish to state clearly and officially that I have no axe to grind and that I have no personal ambition with respect to this project. I feel very deeply that it should be carried out by the Geological Survey and that it deserves some of the best geologists, best administrators, best coordinators, and best diplomats that the Survey has at its command. I do not consider that I belong in any of these categories, and feel sure that my long-suffering superiors in the Fuels Branch will agree that this statement is made with no sham attempt at false modesty.

David Love

Written at Laramie, Wyoming
February 25, 1949

The Denver Post/Sunday, December 21, 1986

Awards

Top scientist

J.D. Love, a Wyoming geologist, has received the Scientist of the Year award from the Rocky Mountain Association of Geologists. Love has been with the U.S. Geologic Survey for over 40

USGS
Box 3007
Univ. Station
Laramie, 82071

SUGGESTED RESEARCH PROGRAM ON GEOLOGY AND RELATED STUDIES OF POISONOUS ROCKS

GENERAL STATEMENT

The agricultural economy of the western United States is dependent on two factors:

1. The amount of range land that is safe for livestock raising.
2. The amount of land that has been or is planned to be put under cultivation that is safe for raising crops.

The word "safe" is used here to mean both safe from a public health standpoint and safe from the standpoint of sound economics.

The rocks and soils at the surface of the ground in large areas of the western United States (See Plates 6, 8, 10, 12, and 14) contain minute quantities of certain poisonous elements, chiefly selenium, but to a lesser extent molybdenum, tellurium, and other elements as yet unidentified. These poisonous elements, particularly selenium, are absorbed by plants of many types (See Plates 2 and 3) and by eating these plants, both human beings and livestock are poisoned (See Plate 1). This fact has been conclusively demonstrated by Beath and his coworkers at the University of Wyoming and by Byers, Lakin, and coworkers in the U. S. Department of Agriculture. Under average conditions these poisons accumulate slowly, in the same manner as arsenic or lead poisoning, and either permanently injure (Plate 1) or kill the individual. These poisons are in no way related to loco weed, larkspur, lupine, or death camas.

These poisonous elements are confined to certain specific geological rock formations (See Plates 4, 5, 7, 9, 11, and 13) and to soils derived from them. Therefore, by mapping geologic contacts, the geologist is also mapping the boundaries of the poisonous rocks. In this way it is possible to estimate and predict the location and extent of areas where selenium poisoning may occur or does occur (See Plates 6, 8, 10, 12, and 14), depending on what type of vegetation is present.

The following conservative estimate made in this manner indicates the magnitude of the problem confronting the economy of the western United States:

In Montana, approximately 30% of the state has at the surface seleniferous rocks that are actively or potentially poisonous. The figure for Wyoming is 20%, for Colorado 30%, for the northern half of Arizona 20%, for the northern half of New Mexico 40%, for Utah 25%. In short, thousands of square miles of land in these regions are now, or may become poisonous to livestock that graze there and to human beings that live there, and crops that are raised there may be poisonous.

The most common effect on the economy of a region is one of gradual progressive debility. However, there are many cases of the acute rapid type of poisoning (Plate 1, fig. 1) by these elements that total several million dollars in livestock losses per year, in the Rocky Mountain region alone. The losses in terms of debilitation, sterility, crippling, and suffering (Plate 1, figs. 2, 3, and 4) cannot be estimated. More tragic still are the wasted years of hard work, the broken homes, the blighted lives, and the abandoned farms and ranches of those people

who homesteaded or bought places without realizing they never had a chance to succeed because of these poisonous elements in the ground. They fail without knowing why they failed.

One objective of this program is to obtain the knowledge necessary to prevent these failures and losses in areas where they can occur but have not as yet. There is little hope of rehibilitating seleniferous land. The hope lies in recognition of such lands and in intelligent use of them in ways where the poisons have no chance to operate.

The variety of problems created by these poisons is incredible, and can best be illustrated by a number of isolated examples.

1. Approximately 60% of the Navajo, Hopi, Apache, and Kaibab Indian Reservations in Arizona and almost 100% of the Navajo Reservation in New Mexico have at the surface seleniferous rocks that are actively or potentially poisonous. It is no wonder that the economy of these Indians is in terrible condition and their health and that of their livestock is poor. The government has poured hundreds of thousands of dollars into the support of these Indians, yet it has totally disregarded the fact that more than half of the land allocated to them is now or probably will become poisonous. No attempt has ever been made to determine the extent of damage to the people and livestock here by these poisons. In all the planning to revive the economy and health of these people, no thought is being given to securing the facts concerning the extent, distribution, and effect of these poisons in this region (letter from Mr. Krug's office to Mr. Beath, May , 1948.) One objective of this program is to secure the basic data necessary to evaluate these lands. Only in this way can an intelligent plan for the future be worked out, without wasting millions of dollars of taxpayers money.

2. The most poisonous area known in the world covers about six square miles in central Wyoming. The vegetation here is identical in appearance to that in adjacent areas, yet it is known to have killed 2800 sheep in 24 hours. At current prices, this is a loss of more than $60,000.00. This loss could have been prevented, had there been adequate geologic knowledge of this area. Other localized areas where tremendous concentrations of selenium are known ~~as~~ are: Seeman Buttes, South Dakota, Poison Buttes, Wyo., and the uranium-vanadium strip in southeast Utah. One of the objectives of this program is to determine wherever possible the location and boundaries of additional similar areas of great potential menace in the western United States.

3. A livestock company in Wyoming spent $40,000.00 to put water on approximately 1,000 acres of land in a very desirable location, and in addition built an irrigation system, large buildings, and many fences. The first year a bumper crop of hay was cut. The horses that ate the hay lost their hair and were severely debilitated or died and the cattle were similarly affected. The second year losses were greater and debilitation increased to the point where the entire ranch had to be abandoned. Adequate geologic, chemical, and botanical information would have indicated what the conditions were in advance and thus saved the company the entire investment and many man-years of hard labor.

4. The Bureau of Reclamation has embarked on a tremendous regional program involving the Missouri River Basin, Columbia River Basin, Colorado River Basin, and other areas. Many of the individual projects within these areas, such as the Fort Peck project in Montana, the Republican River project in Nebraska, the Bighorn Basin project in

Wyoming, and projects in North and South Dakota, involve large areas where there are surface exposures of actively or potentially poisonous soils and rocks. A few years ago construction on a Reclamation project involving an expenditure of approximately $30,000,000.00 was well advanced when it was discovered that approximately half of the area to be irrigated had at the surface, actively or potentially poisonous shales. This required some drastic changes in plans. If adequate coordinated geological, chemical, and botanical data had been available during the initial stages of planning of this project, several millions of dollars and many man-years of labor would have been saved.

5. Ambitious projects for reseeding vast areas of the western United States are in progress. These projects involve expenditure of large amounts of money. Little if any attempt has been made to determine whether the areas that have recently been reseeded or that are to be reseeded in the near future are on actively or potentially poisonous rocks and soils. Three reseeding projects in Wyoming alone, involving approximately 30,000 acres, have at the surface actively or potentially poisonous shales covering more than 60% of the area. Coordinated geological, chemical, and botanical data available during the initial stages of planning of these projects would avoid tragic mistakes and waste of money. Only by consideration of such data can maximum use of these appropriations and maximum value of labor be obtained.

6. Underground waters have recently been found to contain such quantities of selenium that they are poisonous to livestock. Routine analyses of quality of water do not include tests for selenium and other poisonous elements. The regional extent of damage to livestock

from the use of poisonous underground water is not known, but deserves considerable investigation.

7. In central Mexico, near Irapuato, a community with a population of more than 35,000, the people and animals have suffered from a strange affliction for more than 200 years (U. S. D. A. Tech. Bull. 702). It first appeared when the local silver mines began to treat the silver selenide ores by the patio process. The selenium-bearing slime waste from the processing of these ores was dumped into the Guanajuato River which spread them over its flood plain. The river water was used for irrigation and thus further spread the selenium. All the vegetation and even manure used for fertilizer contain high concentrations of selenium. Selenium was found in the vegetables, meat, and milk consumed locally. Under these conditions neither the people, the livestock, nor the vegetation ever has a chance to be normal and healthy. The history of disease, suffering, and death in this community is appalling.

8. A recent study of 111 families in known seleniferous areas of Wyoming, South Dakota, and Nebraska showed that 95% of the subjects had selenium in the urine. There was an abnormally high incidence of more or less serious damage to the liver, kidneys, skin, and joints, and digestive disorders were common.

9. Because of its reputation as a poisonous area, a tract of 100,000 acres in South Dakota was withdrawn by the government from wheat cultivation. Most other farming areas in the western United States are not as well known as South Dakota. It is impossible to evaluate at the present time the amount of grains of various types, vegetables, and

other crops, and meats that contain selenium and other poisons that are shipped to markets from poisonous areas. The effects of these products on public health have not been evaluated.

OBJECTIVES

Primary objectives:

1. Determination of which range lands are safe for livestock raising and which are unsafe.

2. Determination of which lands that are now under cultivation or that are planned to be put under cultivation are safe for raising crops, and which are unsafe.

Secondary objectives:

1. Preparation of areal geologic maps of actively or potentially poisonous districts.

2. Determination of the local and regional relationships and continuity of rock units containing selenium and similar poisons, and determination of local distribution within each unit.

3. Preparation of geological, geochemical, and geobotanical maps of poisonous areas, simplified for use by farmers, ranchers, chemists, botanists, physiologists, and the general public.

4. Determination of the relationship pattern between selenium and vanadium and other trace elements.

5. Evaluation of certain plants as indicators of underlying mineral deposits. This study will involve investigations in known mineralized areas, for control purposes.

6. Investigation of any plants that may themselves concentrate trace elements in commercial quantities. ??

7. Determination of all types of accumulative poisons that affect land, vegetation, livestock, and human beings, and investigation of the possibility that some might be used industrially or have some other practical value.

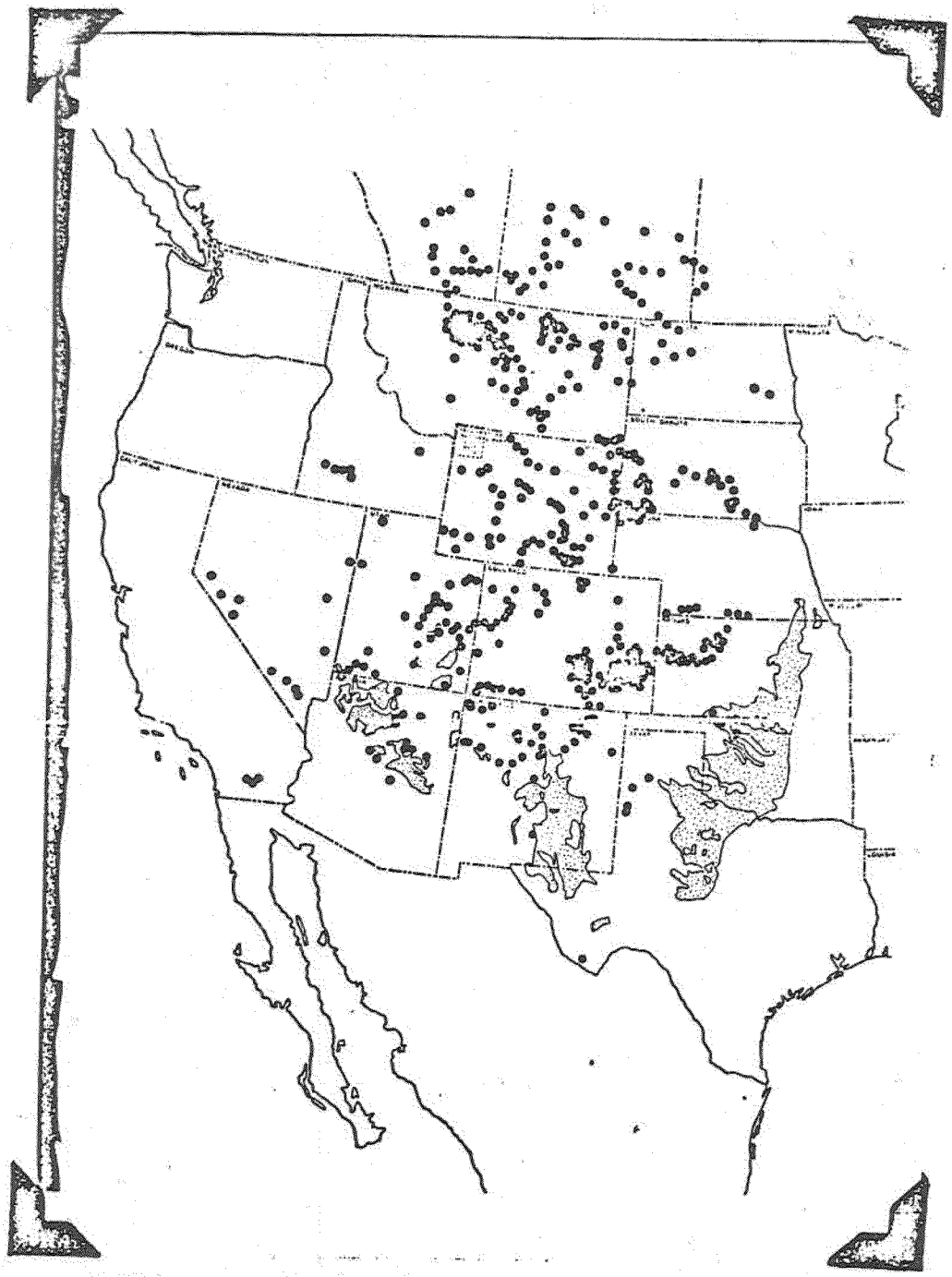
8. Determination of what elements make vegetation grow unusually large and luxuriant in certain heavily mineralized areas. If the geologic reasons can be determined, hitherto unknown areas capable of tremendous production may be recognizable.

9. Determination and evaluation of certain plants as concentrators of selenium poison. For example, 24 species of Astragalus out of several hundred species, all species of Stanleya, all species of Xylorrhiza, and all species of Oonopsis so far analyzed are known, through work of Beath and associates, to be selenium concentrators. It is likely that there are many others not known at present that will be discovered by additional investigations. The Department of Agriculture,

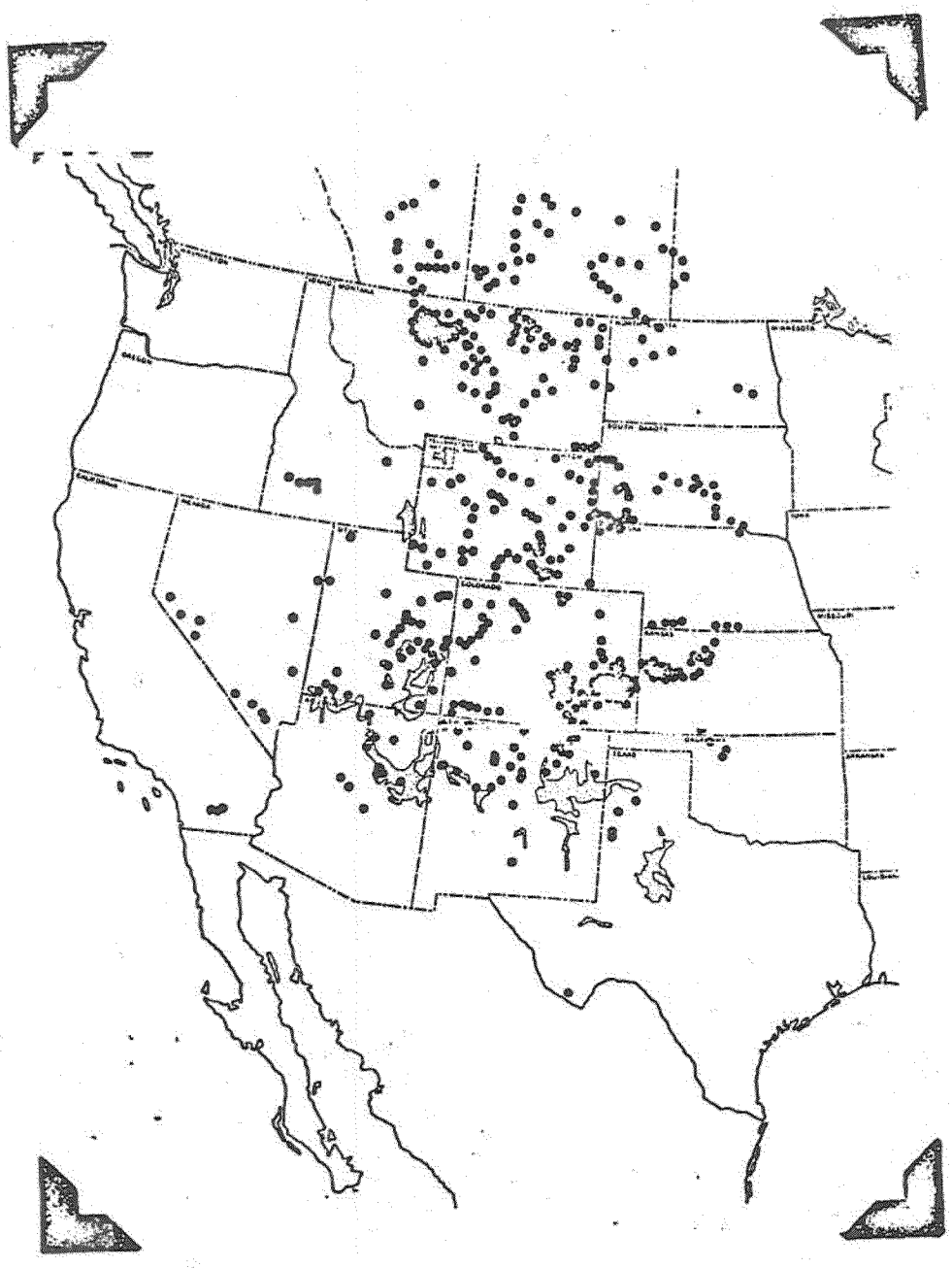
which formerly did considerable work in this field has terminated essentially all such investigations, and the University of Wyoming has terminated its work outside of Wyoming. No similar studies have been made in any other Rocky Mountain states except South Dakota.

10. Compilation of specific data on history of livestock losses, livestock debility, and human ailments in poisonous areas over a period of years. Geologists often work in remote areas where few other scientists ever get, and therefore are in a position to acquire data that will be invaluable to the Public Health Service, physiologists, and chemists.

11. Collection and analysis of surface and underground waters from poisonous and potentially poisonous areas.



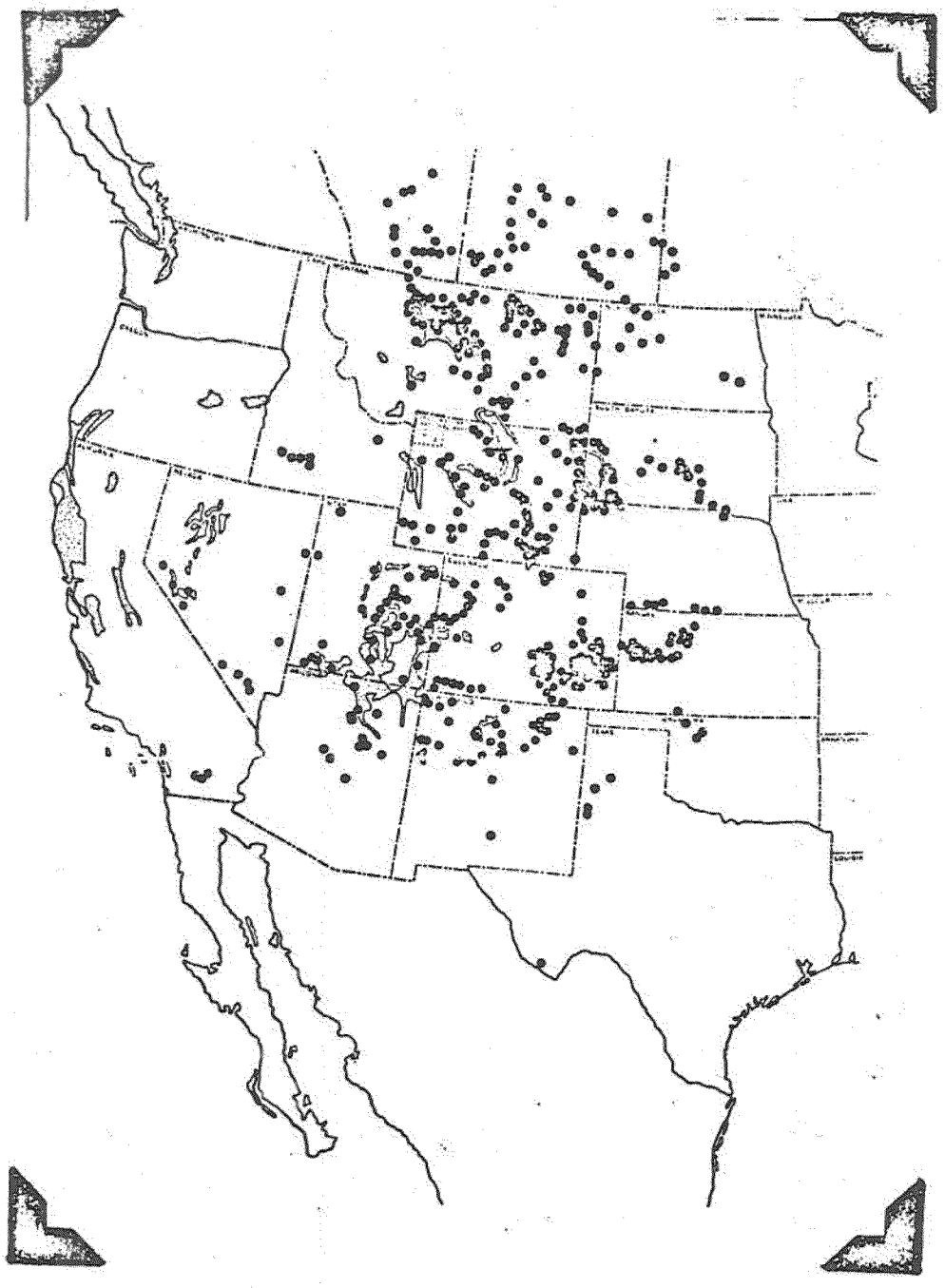
Map 1. Stippled areas show broad outcrops of Permian rocks in Western United States. Black dots show location of plant samples containing 50 or more parts per million of selenium.



Map 2. Stippled areas show broad outcrops of Triassic rocks in Western United States. Black dots show location of plant samples containing 50 or more parts per million of selenium.

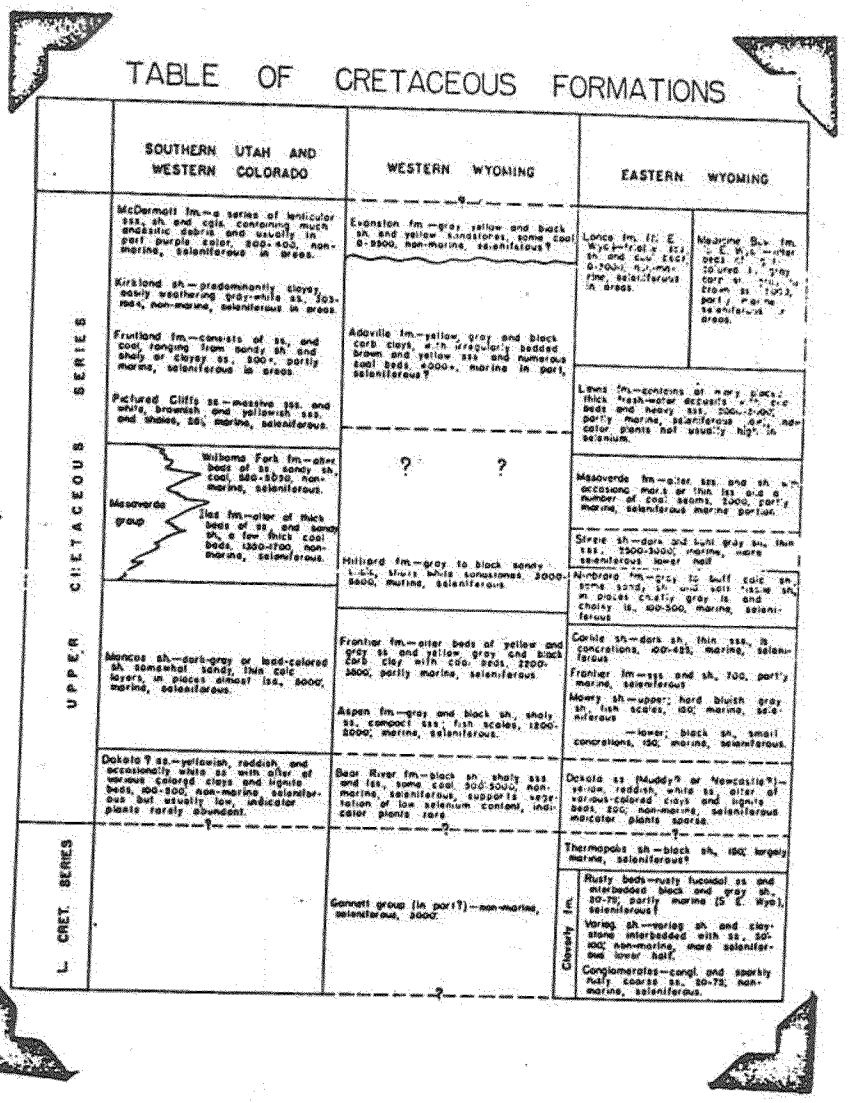
TABLE OF PERMIAN FORMATIONS

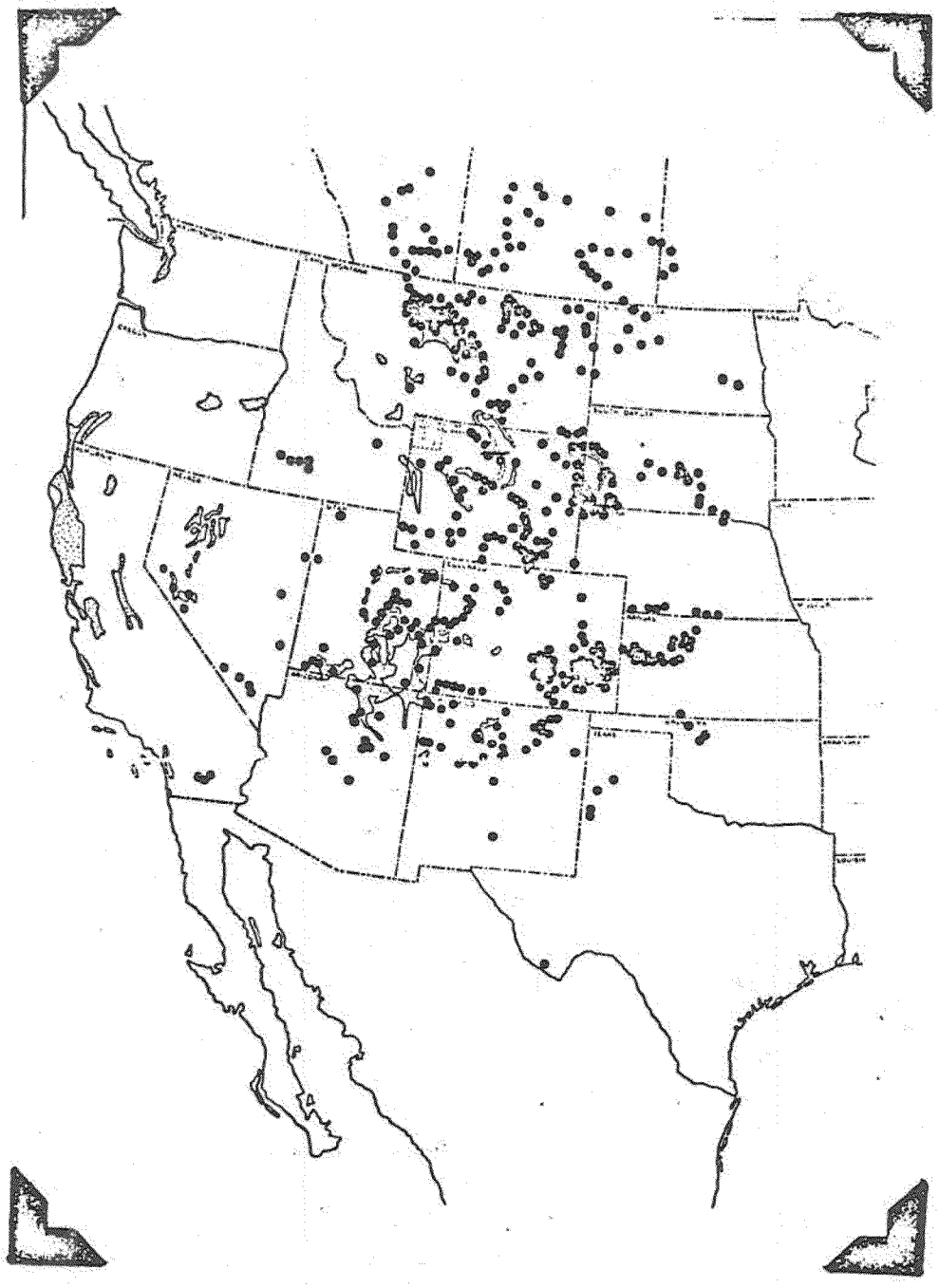
	NORTHERN ARIZONA	S.W. COLORADO	WESTERN WYOMING	EASTERN WYOMING
UPPER				
MIDDLE			PHOSPHORIA FM.- Phosphatic shales, some thin lss., 75'-627', marine, seleniferous.	FREEZEOUT TONGUE OF CHUGWATER Lower Part. Seleniferous. FORELLE LS.- Bluish grey compact ls., much gypsum, 0'-30', marine, non-seleniferous. SATANKA SH.- Sandy red sh., thin lss. and sss., some gypsum, 0'-240', marine, non-seleniferous.
	KAIBAB LS.- ls., contains chert, 820', marine, non-seleniferous. COCONINO SS.- Cross-bedded grey to white ss., 50'-610', non-marine non-seleniferous. HERMIT SH.- Deep brick-red sandy shs., fine-grained friable sss., thin platy lamination, 'red beds', 75', non-marine, seleniferous? SUPAI FM.- Red sss. and shs., 1400', non-marine, seleniferous.	CUTLER FM.- "Red beds" complex of bright red sss. and lighter red or [illegible] with sandy sh. and earthy or sandy lss. of varying shs. of red, 1000', non-marine, seleniferous.		
LOWER		RICO FM.- "Red beds", sss. and cgls. with intercalated shales and sandy fossiliferous lss., 300', marine in part, seleniferous.		



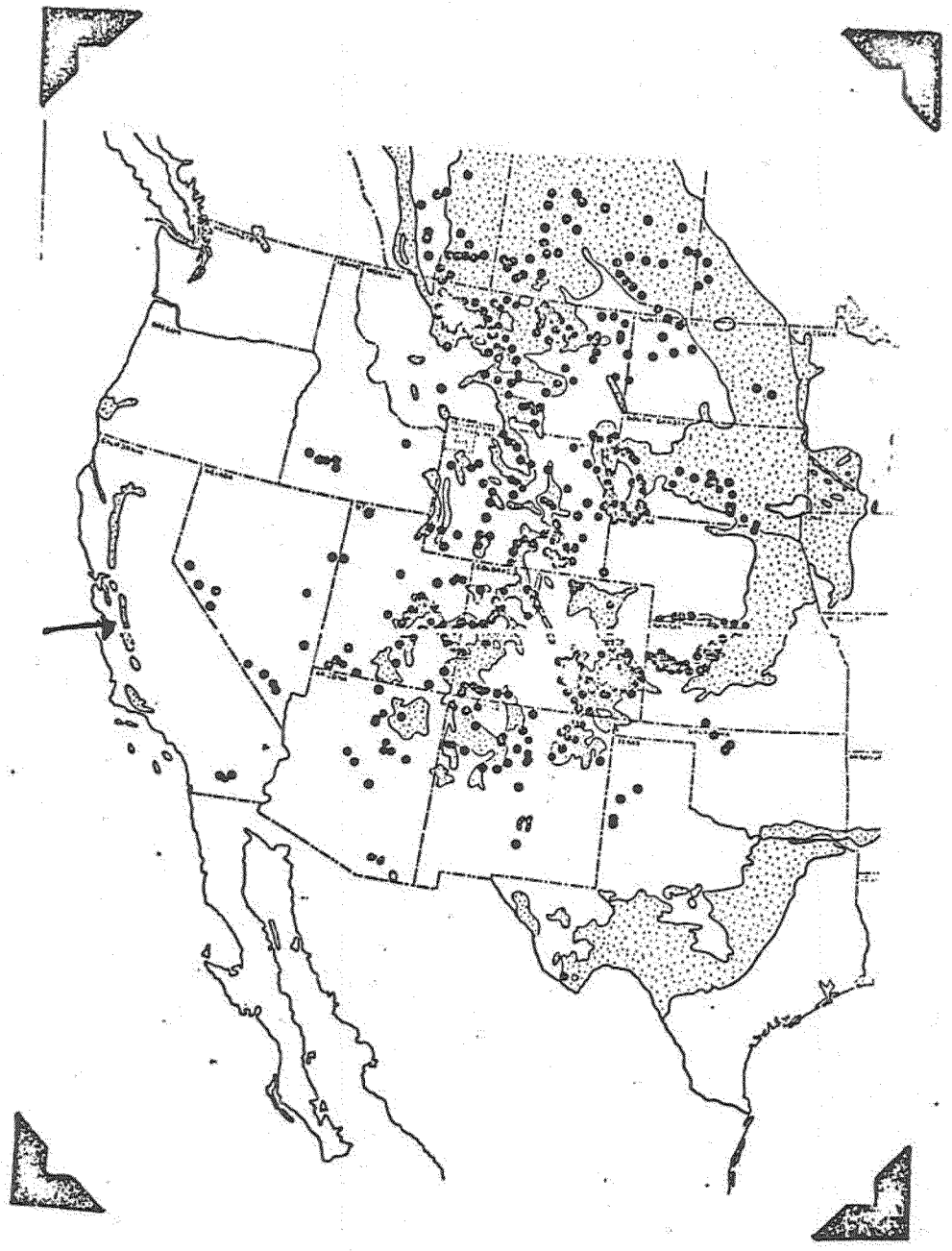
Map 3. Stippled areas show broad outcrops of Jurassic rocks in Western United States. Black dots show location of plant samples containing 50 or more parts per million selenium.

TABLE OF CRETACEOUS FORMATIONS





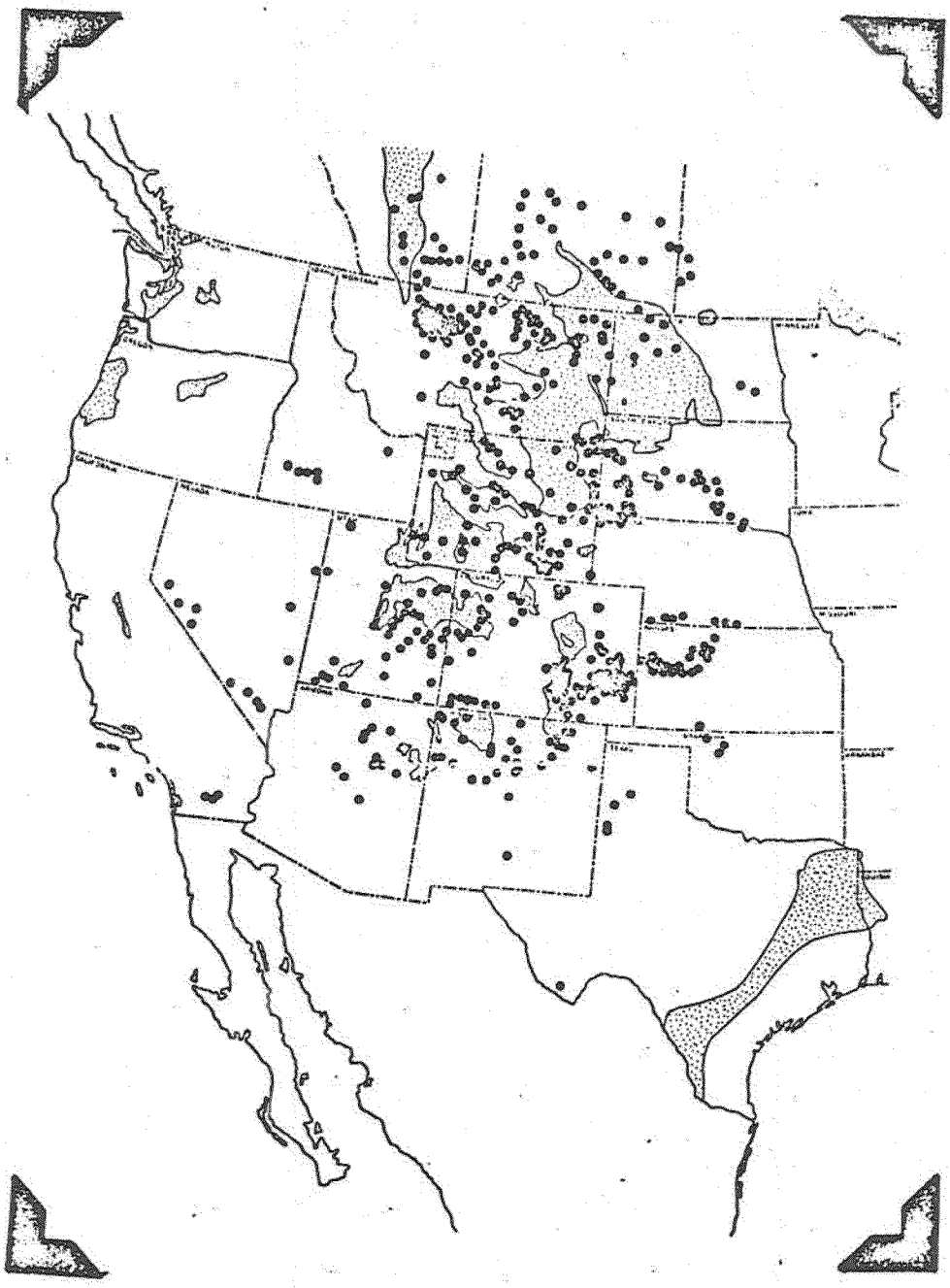
Map 3. Stippled areas show broad outcrops of Jurassic rocks in Western United States. Black dots show location of plant samples containing 50 or more parts per million selenium.



Stippled areas show broad outcrops of Cretaceous rocks in western United States and Canada. Black dots show location of plant samples containing 50 or more parts per million of selenium.

TABLE OF TERTIARY FORMATIONS

	CENTRAL EASTERN UTAH	WESTERN WYOMING	EASTERN WYOMING
PLEIST. SERIES	Alluvium	Alluvium	Alluvium
	Terrace deposits	Terrace deposits Glacial drift	Terrace deposits Glacial drift
PLIOCENE SERIES			North Park fm. — [illegible]
MIOCENE SERIES	Bishop cglt. — boulders and pebbles of [illegible]	Bishop cglt. — boulders and pebbles of [illegible]	Arikaree fm. — sand, [illegible]
OLIGOCENE SERIES	Duchesne River fm. — [illegible]		White River group: Brule clay — [illegible] Chadron fm. — [illegible]
EOCENE SERIES	Uinta fm. — [illegible]	Uinta fm. — [illegible]	
	Bridger fm. — [illegible]	Bridger fm. — [illegible]	
	Green River fm. — [illegible]	Green River fm. — [illegible]	
	Wasatch group — [illegible]	Wasatch group: Knight fm. — [illegible]	Wind River fm. — [illegible]
		Wasatch group: Fowkes fm. — [illegible]	
	Tuscher fm. — [illegible]	Wasatch group: Almy fm. — [illegible]	
PALEOCENE SERIES			Fort Union fm. — [illegible]



Stippled areas show broad outcrops
Map 5. ^ ~~Occurrence~~ of Eocene and Paleocene rocks in western United States and Canada. Black dots indicate location of plant samples carrying 50 or more parts per million of selenium.